Small-scale Forestry (2012) 11:101–117
DOI 10.1007/s11842-011-9171-1

An Economic Evaluation of a Small-Scale Timber Harvesting Operation in Western Maryland, USA

Stuart A. Moss · Daniel B. Hedderick

Accepted: 26 April 2011 / Published online: 7 May 2011

Abstract As forests of the eastern United States become fragmented into smaller ownership parcels, there is a growing need for timber harvesting contactors who can economically harvest timber and perform silvicultural operations on small tracts. Traditional large-scale harvesting operators are ill-suited for work on small parcels, due to their high fixed costs. By contrast, small-scale operators, characterized by few workers and low capital investment, offer an opportunity to serve this landowner segment. This paper presents financial and productivity results from a small-scale timber harvesting pilot study conducted on small forested parcels in western Maryland, USA. Acceptable financial performance is possible for these operations, provided that the operator pays close attention to the important factors determining productivity and profitability, including: (1) average tree volume, (2) net delivered price, (3) time utilization, and (4) distance to the site. Although profitable harvesting of saw log quality trees on parcels less than 10 ha is possible, harvesting of small or poor-quality trees remains economically unattractive.

Keywords Private forest owners · Forest fragmentation · Small forest parcels

S. A. Moss (✉)
Division of Forestry and Natural Resources, West Virginia University, PO Box 6125, Morgantown, WV 26506-6125, USA
e-mail: Stuart.Moss@mail.wvu.edu

D. B. Hedderick
Maryland Department of Natural Resources, Forest Service, 3 Pershing Street, Room 101, Cumberland, MD 21502, USA

Introduction

Owners of small forestland parcels in the eastern United States face daunting challenges when attempting to engage in timber harvesting on their forests (Kittredge et al. 1996; Londo and Grebner 2004; Row 1978). Modern timber harvesting contractors are highly capitalized operations with a significant investment in large-scale equipment designed to leverage labor productivity to a very high level (Milauskas and Wang 2006). As a result of their significant capital investment and corresponding high fixed costs, conventional harvesting contractors face considerable transportation and set-up expense when moving from site to site. These costs are manageable so long as they can be spread over a significant harvest volume. As tract size decreases, however, these costs must be spread over a smaller harvest volume, driving unit costs up. Per-unit harvesting costs generally begin increasing significantly as parcel size falls below 20 ha. Below 10 ha, timber harvesting is often uneconomical unless the timber is of very high quality and the harvest volume per hectare is also high (Cubbage 1983a; Cubbage et al. 1989; Greene et al. 1996; Kittredge et al. 1996).

In addition to transportation and set-up costs, large-scale harvesting operations face significant monthly fixed costs and often incur large hourly operating costs. Generally, the high productivity achieved by these operations more than offsets these higher costs, resulting in improved profitability (Cubbage 1983b). However, when productivity is limited by site conditions or other factors, such as sites with small average tree size or low harvest volume per acre, it is difficult to achieve the productivity levels required to sustain profitability with highly-capitalized operations (Cubbage et al. 1989; Li et al. 2006). If tract size is also small, the obstacles to profitability are often insurmountable.

With a continued reduction in parcel size in many areas of the eastern United States, an increasing number of forestland owners may be in possession of forest parcels too small for economic timber harvests and related timber stand improvement operations (DeCoster 1998). More than 75% of the forest landowners in Maryland own 4 ha or less (Maryland DNR 2001). In neighboring West Virginia, about 70% of the state's forest landowners own 8 ha or less (West Virginia DOF 2010). In developing areas, not only is forestland being cleared for non-forest uses, but much of the remaining forestland is being rendered uneconomical for forest management due to small parcel size.

In response to these concerns, the Maryland Department of Natural Resources initiated the Working Woodlot Initiative Project to examine the feasibility of developing small-scale timber harvesting contractors to perform timber harvesting and associated timber stand improvement on small forested parcels (Hedderick 2008). Small-scale harvesting operators are characterized by a limited amount of capital investment in equipment, all of which is smaller than conventional harvesting equipment (Wilhoit and Rummer 1999; Updegraff and Blinn 2000). These operations utilize a limited number of employees, often just the owner-operator, possibly assisted by one or two employees. This paper examines the economic feasibility of a small-scale timber harvesting operator and identifies the important factors that determine profitability for these operations.

Methodology

Five privately owned, non-industrial forestland parcels in Allegheny County, Maryland, USA were selected for this project. The sites ranged in size from 1.4 to 3.5 ha and were selected to provide a range of site and stand conditions. Private consulting firms performed pre- and post-harvest inventories and marked the stands for harvest. All sites were marked for a crop-tree release, whereby the better quality trees were selected as crop-trees to be retained in the future stand and trees in the vicinity of the crop trees were harvested. Average stem diameter increased after harvest on every site except Site 4, where there was a decrease. The percentage of acceptable growing stock in the stand (trees of desirable species, form and vigor) increased after harvest on every site except Site 3, where it remained unchanged.

Four of the five sites were located within 10 km of the operator's place of business, with an average distance of 4 km. One site (Site 3) was 41 km from the operator's place of business. In order to make the cost analysis of this site compatible with the other sites, travel expense was adjusted for Site 3, assuming the site was 4 km from the operator's place of business. The impact of distance to the site on profitability was analyzed separately.

The owner-operator who performed the harvesting was a sole proprietor, assisted part-time by one family member. Equipment consisted of a commercial-grade chainsaw, a four-wheel-drive all-terrain vehicle (ATV), and a wheeled skidding arch. The skidding arch was purchased after the first three sites were completed and was used only on the final two sites, which had larger average tree sizes. The contractor also used a personal four-wheel-drive pick-up truck to travel to the sites, transport equipment and firewood to and from the sites, and deliver firewood to customers. The operator was responsible for felling, bucking and skidding logs to the landing. Veneer and saw logs were sold at the landing to various mills, at the operator's discretion. The operator paid a trucking contractor to load and transport the logs to the mills. Firewood and fence posts were generally sold at the landing with the buyer responsible for transportation from the site. During the early part of the project, the operator hauled most firewood to his place of business where it was split, seasoned, and delivered to buyers. Due to the considerable time and expense involved, the operator ceased handling firewood in this manner after Site 2 and sold all firewood at the landing.

The operator negotiated stumpage payments with each individual landowner. Although terms varied somewhat from site to site, in general the operator paid the landowner US\$10 per standing cord (3.63 m^3) for firewood and 40–50% of mill receipts (delivered log revenue) for veneer and saw logs.

The operator maintained daily activity logs recording the following information: (1) weather and site conditions, (2) hours worked, (3) description of work done and equipment used for each time entry, (4) vehicle distance driven, (5) amount and description of all business-related expenses, (6) volume of timber harvested or sold, by species and product type, and (7) sale revenue.

Labor time was classified into the following categories: (1) Field (felling, topping, skidding, bucking and loading), (2) Maintenance and Repair, (3)

Preparation and Reclamation (landing and skid trails, seeding and mulching) and (4) Other (splitting and hauling firewood, equipment transportation and administrative).

The 21-month term of the project included considerable idle time between sites as the operator waited for timber marking to be completed, contract preparation, etc. Although there would be similar idle time in a commercial harvesting operation, the idle time during this project was excessive due to the research project requirements. For this reason, income statements for the business reflect expenses for only the 13 months during which the operator was active. These 13 months include idle time that is part of any commercial harvesting operation, such as inclement weather, poor working conditions, equipment failure, holidays, etc. This presentation of financial results is also more useful for modeling break-even quantity and profit potential.

Sites 1 and 2 contained a much larger proportion of smaller and poorer-quality trees compared to Sites 3–5 (Hedderick 2008). In addition, the operator spent considerable time splitting and delivering firewood during operations on Sites 1 and 2, but ceased these activities on the remaining sites due to the time and expense involved. As a result of these differences, separate income statements were prepared for Sites 1–2 and Sites 3–5. As with the income statement for the entire project, finances were stated for the period during which the operator was active on these sites, including idle time while on a site (due to weather, etc.), but excluding idle time between sites.

Capital assets (all-terrain vehicle, skidding arch, and chainsaw) cost a total of US$11,181 and were depreciated over a 5-year useful life, using straight-line depreciation and assuming full-year depreciation during the first year (i.e. 20% of asset cost was depreciated each year). This method was chosen so that depreciation expense would be consistent throughout the entire project, rather than increasing during the second year, as would be the case using accelerated cost recovery methods or using the half-year convention rule as required by the Internal Revenue Service. Depreciation expense was adjusted after the first three sites to reflect the purchase of the skidding arch, costing US$1,831. Accordingly, the depreciation expense for Sites 1–3 was US$156.83 per month and increased to US$186.35 per month for Sites 4 and 5. The operator also paid US$56.35 per month for liability insurance, resulting in a total fixed cost of $212.18 per month for Sites 1–3 and $242.70 per month for Sites 4–5.

Variable costs include those items used directly in production, such as gasoline and oil for the ATV and chainsaw; chains and bars for the chainsaw; and seed and straw for reclamation. Incidental expenses (office supplies, postage) were included with variable costs for simplicity. Field variable cost (variable cost per field hour, excluding vehicle expense) was calculated for each site and vehicle costs were tracked separately to facilitate an analysis of distance to site on profitability.

The operator's use of his personal vehicle for transportation to and from the site and hauling firewood was expensed at the Internal Revenue Service's 2006 reimbursement rate of US$0.276 per km or US$0.445 per US mile (Internal Revenue Service 2005). This allowed for consistency in our analysis by eliminating the variability in purchase price and operating and maintenance expenses incurred with various types of vehicles that might be purchased by small-scale harvesters.

Actual costs of vehicle ownership during this project were close to the expenses recorded using the IRS reimbursement rate.

Wages were not included as an expense item on the income statements so that business income could be used to calculate an equivalent wage rate earned from a small-scale harvesting operation. Earnings before interest and taxes (EBIT, or operating income) were divided by the total number of hours worked to calculate the equivalent wage rate for each site.

Break-even quantity (BEQ), defined as quantity of timber which needs to be produced each month to cover fixed expenses, was calculated for the entire project. BEQ was stated as a function of various site and operating factors (productivity, net delivered price and distance to site) which vary between sites. An equation was also developed to estimate the equivalent wage rate as a function of these factors.

The total number of hours worked and the number of field hours worked was tabulated for each site and the relative percentage of time spent on various activities was calculated.

Labor productivity (tonnes produced per field hour worked) was calculated for each site. Because of some potential discrepancy with the production data, Sites 1 and 2 were combined for labor productivity analyses. Least squares regression was used to predict labor productivity as a function of average tree volume (tonnes per tree).

Results

Income Statements

Income statements for the Working Woodlot Initiative Project are presented in Table 1.

Since wages were not considered as an operating expense, business income was used to calculate an equivalent wage rate for the owner-operator. For the entire project, the operator and his assistant worked 1,386 h, earning a pre-tax income of $9,349 and an equivalent wage rate of US$6.75 per hour. As a result of a higher proportion of sawtimber and a change in operations (less time spent splitting and delivering firewood), Sites 3–5 were significantly more profitable, with an equivalent wage rate of US$10.71 per hour. The operator generated very little income on Sites 1–2 ($587) and earned an equivalent wage rate of only US$1.03 per hour.

Time Utilization

Data from the time utilization analysis is presented in Table 2. For the entire project, 70% of the hours worked were productive field hours. However, this figure ranged from a low of 49% on Site 1 to a high of 83% on Sites 4 and 5. This variation is due to significant time spent splitting and delivering firewood ("Other" category) while working on Sites 1 and 2. Once the operator began concentrating on harvesting, more than 80% of the total hours worked were spent in the field. As

Table 1 Income statements for the harvesting operation for all sites, Sites 1–2, and Sites 3–5

Revenue/expense item	All sites (13 months)	Sites 1–2 (5.5 months)	Sites 3–5 (7.5 months)
Gross revenues	$20,445	$3,055	$17,390
Less: transportation expense	$735	–	$735
Less: stumpage fees	$4,903	$372	$4,531
Net revenues	$14,807	$2,683	$12,124
Operating expenses			
Fuel, oil, etc. (non-vehicle)	$720	$255	$465
Vehicle use	$1,127	$306	$821
Misc. supplies	$176	$147	$29
Maintenance	$437	$132	$304
General & administrative	$117	$90	$28
Wages	–	–	–
Insurance	$733	$310	$423
Depreciation	$2,148	$857	$1,291
Total operating expenses	$5,458	$2,097	$3,362
Operating income (EBIT)	$9,349	$586	$8,762
Average monthly EBIT	$719	$107	$1,168
Total hours worked	1,385.75	567.50	818.25
Equivalent wage rate (per hour)	$6.75	$1.03	$10.71

expected, maintenance time increased somewhat after Site 2 to an average of 8% of hours worked, as a consequence of normal usage of the equipment. For the entire project, maintenance consumed 6% of total hours worked. Over the long-term, this figure may increase somewhat as equipment wears out. Six percent of the hours worked were spent on pre-harvest preparation of the site and post-harvest reclamation. This figure was fairly consistent throughout the project.

Total hours worked per month ranged from 83.6 on Site 3 to 140.9 on Site 4. Assuming 173 potential working hours per month (21.67 working days per month $\times$ 8 h per day), total hours worked ranged from 48 to 81% of potential working hours (average = 62%). This does not include idle time between sites, but does include idle time during harvesting of a site resulting from inclement weather, inoperable site conditions, illness/vacation time, equipment failure, and landowner requests for work stoppage.

Productive field hours ranged from 43.4 h per month on Site 1 to 117.4 h per month on Site 4. Once the operator began concentrating on harvesting activities, he averaged nearly 90 h of field time per month, or 52% of potential monthly working hours.

Productivity Analysis

Due to an overlap in production data (the operator stockpiled firewood from Site 1 which was sold during harvesting on Site 2), data from Sites 1 and 2 were combined

Table 2 Number of hours worked in various activities by site

Location	Months on site	Total hours	Field[a] hours	P&R[b] hours	M&R[c] hours	Other[d] hours	Hours per month	
							Total	Field
Site 1	3.5	312	152 (49%)	24 (8%)	17 (5%)	120 (38%)	89	43
Site 2	2.0	256	143 (56%)	13 (5%)	4 (1%)	97 (38%)	128	72
Site 3	3.5	293	235 (80%)	17 (6%)	28 (10%)	12 (4%)	84	67
Site 4	2.0	282	235 (83%)	9 (3%)	23 (8%)	15 (5%)	141	117
Site 5	2.0	244	204 (83%)	17 (7%)	14 (6%)	10 (4%)	122	102
Total	13.0	1,386	969 (70%)	79 (6%)	86 (6%)	253 (18%)	107	75
Sites 3–5	7.5	818	674 (82%)	43 (5%)	65 (8%)	37 (4%)	109	90

Numbers in parentheses are percentage of total hours worked

[a] Felling, skidding and bucking operations

[b] Pre-harvest preparation and post-harvest reclamation

[c] Maintenance and repair

[d] Administrative time and time spent loading, splitting and transporting firewood

for productivity and cost analysis (this combination was not necessary for the time utilization analysis).

Production values are shown in Table 3. "Valuable sawlog" tonnage includes sawlog-quality trees of black cherry (*Prunus serotina*), oaks (*Quercus* spp.), ashes (*Fraxinus* spp.), and sugar maple (*Acer saccharum*). The proportion of harvested material that was sawlog quality ranged from 42 to 52% on Sites 3–5, compared to less than 5% on the first two sites. Thirty-four percent of the volume harvested on Site 4 was considered "valuable", compared to less than 20% on the other sites.

Harvested trees/ha and tonnes/ha were considerably higher on Site 4 than on the other sites (Table 4). Average harvested tree volume (tonnes/tree) was considerably higher on Sites 4 and 5 than on Sites 1–3. Labor productivity ranged from 0.45 tonnes per hour on Site 3 to 0.69 tonnes per hour on Site 4 and was much higher on Sites 4 and 5. Not surprisingly, these sites had the largest average harvested tree volume and the highest harvest volume per hectare.

Table 3 Number of trees and quantity of timber products harvested by site

Location	Ha	No. of trees	Total tonnes	Sawlog tonnes	Valuable[a] tonnes
Sites 1 & 2	4.37	417	169.7	8.3	2.8
Site 3	3.52	337	106.7	55.5	19.8
Site 4	1.46	166	161.1	74.3	54.5
Site 5	2.91	174	136.7	57.8	14.1
Total	12.26	1,094	574.2	195.9	91.3
Sites 3–5	7.89	677	404.5	187.6	88.5

[a] See text for description of valuable species

Table 4 Harvest intensity (trees and tonnes per hectare), average tree volume (tonnes per tree), and labor productivity (tonnes per field hour) by site

Location	Trees per Ha	Tonnes per Ha	Tonnes per tree	Field hours	Tonnes per field hour
Sites 1 & 2	95.4	38.8	0.41	295	0.58
Site 3	95.7	30.3	0.32	235	0.45
Site 4	113.9	110.6	0.97	235	0.69
Site 5	59.7	46.9	0.79	204	0.67
Total	89.2	46.8	0.52	969	0.59
Sites 3–5	85.8	51.3	0.60	674	0.60

Using least squares regression analysis, a significant (R-square $= 0.91$) relationship between productivity and average tree volume for this project is expressed by:

$$L = 0.1933 \ln(T) + 0.7088, \tag{1}$$

where $L =$ labor productivity (tonnes per hour) and $T =$ average tree volume (tonnes per tree).

Since productivity is an important determinant of profitability, this equation is useful to determine the average tree volume necessary to ensure the likelihood of a profitable operation.

Cost Analysis

Operating cost data is presented in Table 5. Total and fixed operating costs per tonne were nearly twice as high on Sites 1–3 compared to Sites 4 and 5, while variable costs per tonne were about 50% higher. These differences are mostly the result of higher productivity (tonnes/hour) on Sites 4 and 5 compared to the other sites.

Variable cost per field hour is a critical component of operating cost. Since vehicle use is primarily a function of distance, this cost was analyzed separately from other variable costs. Field variable cost per hour (excluding vehicle cost) declined somewhat after the first two sites, although there was considerable

Table 5 Operating costs per tonne and variable costs per field hour for each site

Location	Operating costs per tonne			Variable costs per field hour		
	Variable	Fixed	Total	Non-vehicle	Vehicle	Total
Sites 1 & 2	$5.48	$6.88	$12.35	$2.12	$1.04	$3.15
Site 3	$5.46	$6.96	$12.43	$1.19	$1.29	$2.48
Site 4	$3.46	$3.01	$6.47	$1.76	$0.61	$2.37
Site 5	$3.72	$3.55	$7.27	$0.65	$1.84	$2.50
Total	$4.49	$5.02	$9.51	$1.50	$1.16	$2.66
Sites 3–5	$4.07	$4.24	$8.31	$1.23	$1.22	$2.45

variability throughout the project. For the entire project, field variable cost averaged US$1.50 per hour.

Break-Even Analysis

Break-even quantity (BEQ) is calculated by the equation:

$$\mathrm{BEQ} = F/(P - V), \tag{2}$$

where BEQ = break-even quantity in tonnes per month, F = fixed cost per month, P = net delivered price per tonne, and V = variable cost per tonne.

Net delivered price is gross delivered price at the mill minus transportation cost and stumpage fees paid to the landowner. Variable cost consists of two components: (1) field variable cost and (2) vehicle variable cost. Field variable cost per tonne is calculated by dividing field variable cost per hour by productivity (tonnes per hour). Vehicle cost per hour is calculated by multiplying the round-trip distance by the IRS reimbursement rate and dividing by an assumed 3 field hours per round-trip. This number was calculated by dividing total field hours worked on a site by the estimated number of round-trips made (total km driven divided by round-trip distance) for each site. This value ranged from 1.6 field hours per round-trip on Site 1 to 5.3 field hours per round-trip on Site 3. This value factors in vehicle use for transporting firewood from the site to the operator's place of business and other miscellaneous use, in addition to daily travel to and from the site. Vehicle cost per tonne is calculated by dividing vehicle cost per hour by productivity (tonnes per hour).

For this project, break-even quantity (tonnes per month) can be stated as:

$$\mathrm{BEQ} = F/\{P - [(V_\mathrm{f}/L) + (0.276D/3L)]\}, \tag{3}$$

where F = fixed cost per month, P = net delivered price per tonne, V_f = field (non-vehicle) variable cost per hour, L = labor productivity (tonnes per field hour), and D = round-trip distance to site (km).

Monthly fixed costs for the operator were US$243, after the purchase of the skidding arch. Field variable cost averaged US$1.50 per hour (Table 5). As noted earlier, productivity for the entire project averaged 0.59 tonnes per hour (Table 4). Net delivered price averaged US$25.79 per tonne for all sites.

Using average net delivered price, average productivity, and a round-trip distance of 16 km (typical for the project), monthly break-even quantity is calculated as follows:

$$\begin{aligned}\mathrm{BEQ} &= \$243/\{(\$25.79 - [(\$1.50/0.59) + (4.416/1.78)]\}\\ &= 11.7\ \text{tonnes per month.}\end{aligned}$$

As expected, given the low capital investment by the operator, break-even quantity is very low. Assuming average productivity, the operator could expect to begin making a profit after working only 20 h each month (11.7 tonnes/month ÷ 0.59 tonnes/h = 19.8 h per month).

However, as net delivered price and productivity change, break-even quantity also changes. On a site 8 km from the operator's place of business (16 km round-

trip), at a productivity level of 0.50 tonnes per hour and a net delivered price of US$15 per tonne, the break-even production quantity more than doubles, to 26.8 tonnes per month, with a corresponding break-even labor quantity of nearly 54 field hours per month. If the round-trip distance increases to 80 km, it is nearly impossible to break even with low net delivered prices, even with very high productivity. Accordingly, close attention must be paid to distance to the site and net delivered price if profitability is to be maintained.

Equivalent Wage Rate Analysis

The basic business income formula is:

$$I = R - (V + F), \tag{4}$$

where I = pre-tax net income, R = revenue, V = variable cost and F = fixed cost. For our project, revenue can be restated as:

$$R = \mathrm{PLH_f}, \tag{5}$$

where P = net delivered price per tonne), L = labor productivity (tonnes per field hour), and H_f = productive (field) hours worked.

Variable cost is a combination of field variable cost and vehicle use cost and can be mathematically stated as:

$$V = H_f[V_f + (0.276D/3)], \tag{6}$$

Inserting Eqs. 5 and 6 into Eq. 4 yields the project income formula:

$$I = H_f(PL - V_f - 0.092D) - F \tag{7}$$

Since wages are excluded from our financial reporting, the equivalent wage rate for the owner-operator is found by dividing monthly income by the total number of hours worked during the month:

$$W = I/H_t \tag{8}$$

where W = hourly wage rate and H_t = total number of hours worked during the month. Productive time utilization (U) is the ratio of productive field hours to total hours worked:

$$U = H_f/H_t \tag{9}$$

Thus, wage rate can be re-stated as:

$$W = UI/H_f \tag{10}$$

Inserting Eq. 7 into Eq. 10 yields the wage rate formula for our project:

$$W = U(PL - V_f - 0.092D) - (UF/H_f) \tag{11}$$

Assuming fixed costs (US$243 per month) and field variable cost (US$1.50 per field hour) incurred during this project, hourly wage rate is a function of productive time utilization, net delivered price, productivity, distance to the site, and number of field hours worked each month. The effect of each factor on wage rate was

calculated by varying each factor individually while holding the other factors constant. Figure 1 shows the effect of productivity on wage rate at various net delivered prices, assuming 90 field hours worked per month, 80% productive time utilization (both averages for Sites 3–5), and a round-trip distance of 16 km (average for the entire project).

At low net delivered prices (US$20 per tonne or less) it is highly unlikely that the owner-operator would earn the US federal minimum wage rate (US$7.25 per hour). By contrast, if net delivered price exceeds US$40 per tonne, the operator should earn in excess of US$15 per hour with reasonable productivity (0.60 tonnes per hour or higher).

Figure 2 shows the effect of number of field hours worked each month on wage rate at various net delivered prices, assuming productivity of 0.60 tonnes per hour, 80% productive time utilization, and a round-trip distance of 16 km.

The effect of number of field hours worked on wage rate is rather minimal, given the constraint of constant productive time utilization (i.e. as the number of field hours worked increases, the number of non-productive hours worked also increases, in order to maintain a productive time utilization of 80%). As the number of field hours worked per month falls below 60, wage rate begins to fall more steeply as fixed costs become a large proportion of total costs.

By contrast, productive time utilization has a much more significant impact on wage rate. Figure 3 shows the effect of productive time utilization on wage rate at various net delivered prices, assuming productivity of 0.60 tonnes per hour, 90 field hours worked each month, and a 16-km round-trip distance.

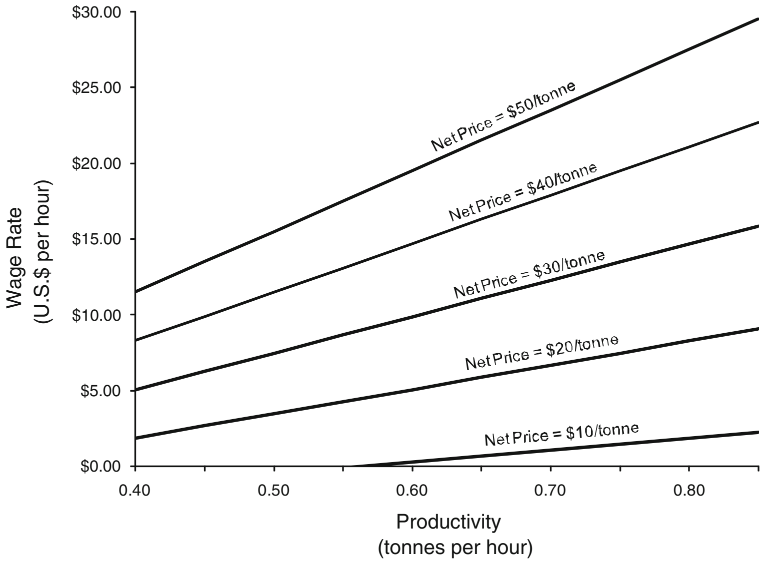

Fig. 1 Effect of productivity on wage rate at various net delivered prices, assuming 90 field hours worked per month, 80% productive time utilization, and a round-trip distance of 16 km

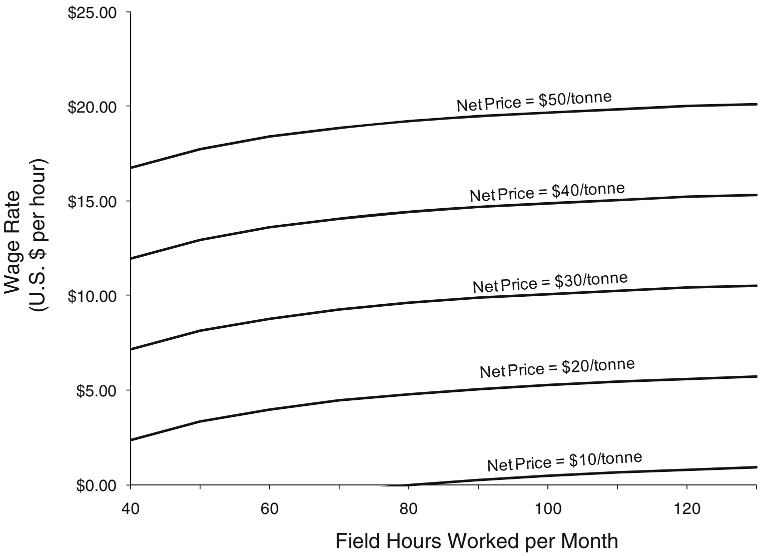

Fig. 2 Effect of number of field hours worked per month on wage rate at various net delivered prices, assuming productivity of 0.60 tonnes per field hour, 80% productive time utilization, and a round-trip distance of 16 km

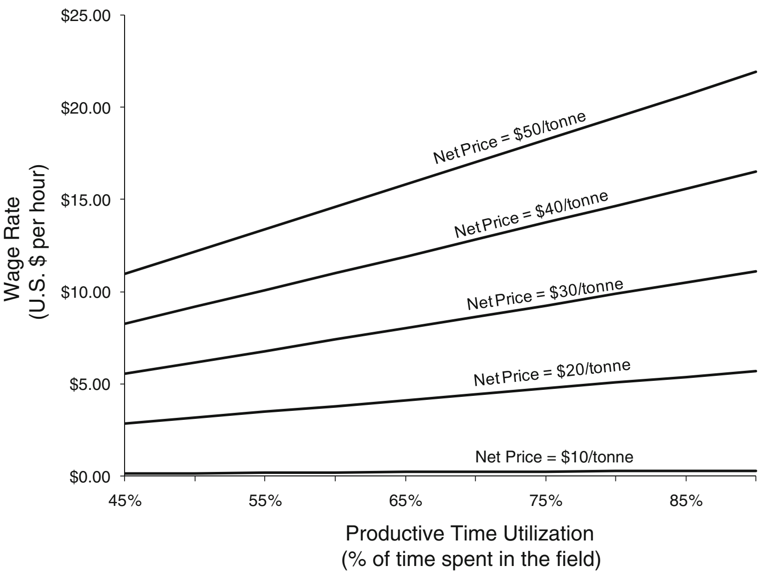

Fig. 3 Effect of productive time utilization on wage rate at various net delivered prices, assuming productivity of 0.60 tonnes per field hour, 90 field hours worked per month, and a round-trip distance of 16 km

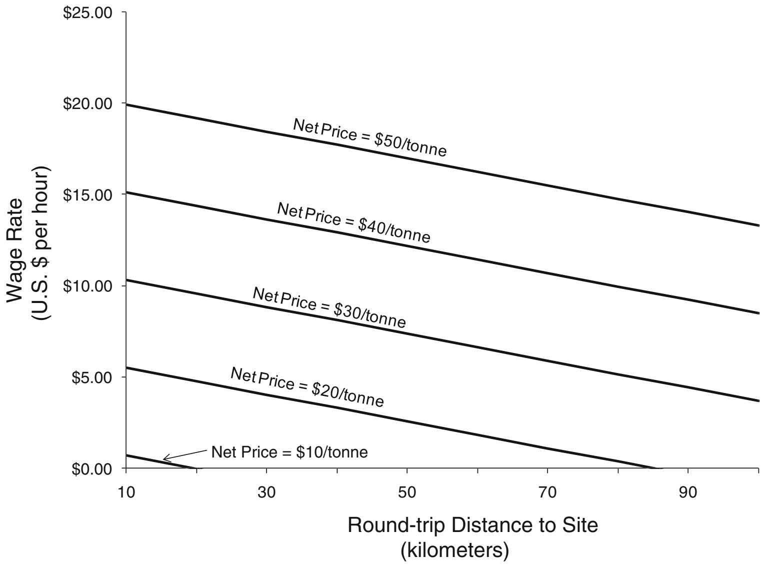

Fig. 4 Effect of distance to the site on wage rate at various net delivered prices, assuming productivity of 0.60 tonnes per field hour, 90 field hours worked per month, and 80% productive time utilization

A decrease in productive time utilization indicates an increase in non-productive work that does not generate any revenue or income. An increase in non-productive hours causes existing income to be spread out over a greater number of hours worked, reducing the wage rate.

At low net delivered prices (US$20 per tonne or less) the owner-operator will earn less than US$7.25 per hour, even with excellent time utilization. By contrast, with net delivered prices above US$40 per tonne, it is possible to earn in excess of US$15 per hour if productive time utilization is kept above 80%.

Figure 4 shows the effect of distance to the site on wage rate at various net delivered prices, assuming productivity of 0.60 tonnes per hour, 90 field hours worked each month, and 80% productive time utilization.

At a net delivered price of US$20 per tonne or less, the operator cannot earn US$7.25 per hour even with a very short distance to the site. At a net delivered price of US$40 per tonne, the owner-operator can earn US$10 per hour as long as round-trip distance is less than 100 km.

Discussion

Overall, the financial performance of this small-scale harvesting operation was disappointing. Even excluding idle time between sites, net income was only US$719 per month with an equivalent wage rate of US$6.75 per hour (Table 1). Generally, this would be considered unacceptable financial performance for a business, as it provides the owner-operator with a wage rate below the current federal minimum

wage rate with no return on his capital investment and no compensation for the risk taken by engaging in business activity.

However, there is reason to be cautiously optimistic about the prospects for profitable small-scale timber harvesting operations. On Sites 3–5, which had a higher proportion of sawlog material marked for harvest, net income averaged US$1,168 per month with an equivalent wage rate of US$10.70 per hour (Table 1). At a wage rate of US$9.00 per hour, the business would have generated a profit of US$186 per month on these sites. With business assets of approximately $11,000, the annualized return on assets on these sites was a very respectable 20%.

By identifying the factors controlling productivity, revenue, and costs, we developed the following guidelines for managing profitability.

Productivity and Average Tree Size

Labor productivity (tonnes produced per field hour) is a fundamental determinant of profitability. Over the term of this project, the operator averaged nearly 0.60 tonnes per field hour, a rate that seems sustainable over the long-term (Table 4). On sites with large average tree volume, productivity of nearly 0.70 tonnes per hour is achievable, as demonstrated on Sites 4 and 5. Although it was not possible to measure the impact of the skidding arch on productivity during this project, it is reasonable to recommend its use on sites with larger trees, due to the expected difficulty of flat-skidding large trees.

Labor productivity of 0.60 tonnes per hour or greater should be obtainable on sites with an average tree volume of at least 0.60 tonnes per tree (Eq. 1).

Net Delivered Price

Net delivered price was one of the most important determinants of income and wage rate for this project and is a function of gross delivered price paid by the mill less transportation expenses and stumpage fees paid to the landowner. Transportation costs can be managed by being aware of distance between the site and various mills. Payment of stumpage fees may be necessary to secure business and is reasonable when the timber is relatively valuable (high proportion of sawlogs and/or high proportion of valuable species). However, on sites with relatively low stumpage value due to tree quality, species, etc., payment of stumpage fees must be carefully considered. This is especially true as distance to the site increases.

Based on data from this project, net delivered prices of $30 per tonne or more significantly increase the profitability of the operation. On sites with lower proportions of sawlog material and valuable species, the operator should consider paying lower (or no) stumpage fees. On sites with little sawlog material, it will be exceedingly difficult to generate a satisfactory wage rate, particularly as distance to the site increases. Despite paying no stumpage fees to the landowner on Site 1 and low stumpage fees on Site 2 (due to the absence of sawlog quality trees), the combined wage rate on Sites 1 and 2 was only $1.03 per hour (Table 1).

Field Hours Worked

Income is directly affected by the number of productive hours worked each month. The operator averaged 90 field hours per month on Sites 3–5, after the operator began concentrating on harvesting operations rather than firewood sales. This level of activity represents about 50% of the potential working hours in a month, and is reasonable for a yearly average, provided sufficient business is available. However, it is recommended that operators exceed 90 field hours per month when weather and site conditions are ideal (e.g. late spring through early fall in the eastern US) in order to compensate for months when working conditions might prevent operators from working 90 h per month in the field.

Productive Time Utilization

Non-productive time does not affect income per se, so long as productive hours worked are unaffected. However, non-productive time does impact the equivalent wage rate. Since no income is generated by non-productive work, income must be spread out over a larger number of total hours, reducing the hourly wage rate.

On Sites 3–5, the operator consistently kept field hours at 80–83% of total hours worked. Thus, it appears that productive time utilization of 80% is sustainable over the long-term. Unless net delivered prices are quite high, such high productive time utilization is necessary in order to earn a satisfactory wage rate.

Distance to the Site

Driving distance from the operator's place of business to the site impacts both net income and the resulting hourly wage rate. Assuming average productivity, net delivered price, and field hours worked, increasing the round-trip distance to the site from 16 to 80 km reduces net income by more than US$500 per month and the equivalent wage rate by more than US$4.50 per hour. However, increases in net delivered price, achievable by reducing stumpage payments to landowners, can compensate for increased distance to the site. At a productivity of 0.60 tonnes per hour, a net delivered price increase of US$1.53 per tonne will roughly offset the additional expense incurred by a 10-km increase in round-trip distance. If productivity drops to 0.50 tonnes per hour, an increase in net delivered price of US$1.84 per tonne is necessary to offset a 10-km increase in round-trip distance. Round-trip distances of less than 20 km are desirable, unless net delivered price can be increased accordingly.

Overall Conclusion

If all of the above-mentioned goals for productivity, net delivered price, field hours worked, productive time utilization, and distance to the site are met, the expected equivalent wage rate (W) calculated from Eq. 11 is:

$$W = 0.8[\$30.00(0.60) - \$1.50 - 0.092(20)] - [243(0.8)/90] = \$9.57 \text{ per hour}.$$

Improvement in any of the above areas would be expected to increase the wage rate. For example, on sites with a large average tree volume and a corresponding high proportion of harvested sawlog volume, productivity of 0.70 tonnes per hour can be achieved (productivity on Sites 4 and 5 averaged 0.68 tonnes per hour). Likewise, a net delivered price of $40 per tonne might be possible on such sites (net delivered price exceeded $38 per tonne on Site 4, even with stumpage payments to the landowner). With good weather and site conditions, 110 field hours per month is a realistic goal (the operator averaged 110 field hours per month on Sites 4 and 5). In this case, the expected wage rate is:

$$W = 0.8[\$40.00(0.70) - \$1.50 - 0.092(20)] - [243(0.8)/110] = \$17.96 \text{ per hour}.$$

This scenario results in a clearly satisfactory financial performance. Although this scenario is somewhat of a "best case" scenario, it is not unrealistic. Financial performance on Site 4 of this project actually exceeded this level.

Conversely, failure to meet any of the targets will be expected to reduce income and wage rate. On sites with small average tree volume and a low proportion of sawlogs (such as Sites 1 and 2), productivity could drop to 0.50 tons per field hour and net delivered price might be only $20 per tonne. Further, inclement weather or other factors might reduce field hours to 70 per month. In this case, the expected wage rate is:

$$W = 0.8[\$20.00(0.50) - \$1.50 - 0.092(20)] - [243(0.8)/70] = \$2.55 \text{ per hour}.$$

This scenario yields an unacceptable wage rate, despite good time utilization and a short distance to the site. The financial performance on Sites 1 and 2 was comparable to this scenario.

As can be seen from this analysis, satisfactory profit and wages can be earned from a small-scale harvesting operation. The variables that are most likely to influence profitability are average tree volume, net delivered price, and distance to the site. Although fixed costs are low, idle time between sites will still affect income. As with virtually any business, satisfactory income will depend on the ability of an operator to maintain a steady flow of work.

As this project has demonstrated, timber harvesting is economically viable on even very small parcels, provided the timber harvested is of sufficient size and quality to ensure adequate productivity and net delivered price. However, the harvesting of small or poor-quality timber is still economically prohibitive unless the operator suspends stumpage payments to the landowner. In extreme cases, it may even be necessary to charge the landowner a fee for performing such timber stand improvement operations. However, small-scale harvesting systems offer other benefits to landowners, including reduced impacts on soils, less damage to the residual trees and improved aesthetics (Hedderick 2008; Updegraff and Blinn 2000; Wilhoit and Rummer 1999). Owners of smaller forested parcels might be willing to trade a reduction in stumpage revenue for these additional benefits, increasing the likelihood of the operator realizing a satisfactory net delivered price.

Acknowledgments The authors would like to thank our harvesting contractor, Matt Diehl, for his significant contributions to this project. We would also like to acknowledge the contributions of Frank Stark and Brian Knox, the forestry consultants who marked the stands for harvest and performed pre- and post-harvest evaluations. Funding for this project was provided by the US Forest Service Innovation Grant and the Maryland Department of Natural Resources, Forest Service.

References

Cubbage F (1983a) Economics of forest tract size: theory and literature. USDA forest service, general technical report SO-41, 21 pp

Cubbage F (1983b) Simulated effects of productivity rates, input costs, and stand volumes on harvesting costs. For Prod J 33:50–56

Cubbage F, Greene W, Lyon J (1989) Tree size and species, stand volume, and tract size: effects on southern harvesting costs. S J App For 13:145–152

DeCoster L (1998) The boom in forest owners—a bust for forestry? J For 96:25–28

Greene W, Harris T, DeForest C, Wang J (1996) Harvesting cost implications of changes in the size of timber sales in Georgia. S J App For 21:193–198

Hedderick D (2008) Small woodlot harvesting: a guide for landowners, land managers and forest products operators. Maryland Department of Natural Resources Forest Service. Cited 17 Nov 2010. Available via http://www.dnr.state.md.us/irc/docs/00013497.pdf

Internal Revenue Service (2005) Rev Proc 2005-78. Cited 17 Nov 2010. Available via http://www.irs.gov/pub/irs-drop/rp-05-75.pdf

Kittredge D, Mauri M, McGuire E (1996) Decreasing woodlot size and the future of timber sales in Massachusetts: when is an operation too small? N J App For 13:96–101

Li Y, Wang J, Miller G, McNeel J (2006) Production economics of harvesting small-diameter hardwood stands in central Appalachia. For Prod J 56:81–86

Londo A, Grebner D (2004) Economies of scale and forest management in Mississippi. In: Connor K (ed) Proceedings of the 12th biennial southern silvicultural research conference, general technical report SRS-71, Asheville

Maryland Department of Natural Resources (2001) Maryland forest stewardship program strategic plan, 2002–2006, Annapolis

Milauskas S, Wang J (2006) West Virginia logger characteristics. For Prod J 56:19–24

Row C (1978) Economies of tract size in timber growing. J For 76:576–579, 582

Updegraff K, Blinn C (2000) Applications of small-scale forest harvesting equipment in the United States and Canada. University of Minnesota Staff paper series no 143, St Paul

West Virginia Division of Forestry (2010) West Virginia statewide forest resource assessment. Cited 17 Nov 2010. Available via http://www.wvforestry.com/DOF100Assessment_Revised_091310_Part1.pdf

Wilhoit J, Rummer B (1999) Application of small-scale systems: evaluation of alternatives. Paper presented at the ASAE/CSAE annual international meeting, Toronto, 18–21 July 1999